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Carbon Emission Forecast of Construction Industry Based on Grey Theory

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Abstract: *In order to reduce emissions of construction industry in China at an early date, this paper provides a fitting of different influencing factors based on the grey correlation method from the construction industry perspective. The correlation degree of carbon emission and related factors in construction industry was ranked as Rate of technical equipment > Practitioners> GDP > Population size > Gross output value of construction industry. And the future of carbon emissions forecast through the grey forecast, found that the country's construction industry will emit more than 80 million tons of carbon in 2030, facing very great pressure to reduce emissions. Therefore, the construction industry should realize the innovation potential of technology and industry model, accelerate the energy transition and achieve the inter-country emission reduction target at an early date.*

Keywords: *Carbon emissions; Construction industry; Grey correlation; Grey forecast*

1. Introduction

With the development of the world economy, the consumption of resources and the worsening of the greenhouse effect are inevitably accompanied by the deterioration of the environment. According to the latest information released by the World Meteorological Organization, the global average temperature in recent years is 32.68°F higher than the average from 1981 to 2010, about 33.8°F higher than the pre-industrial level, and the extreme weather and natural disasters have increased significantly, which has a significant impact on the natural ecological environment and poses a major threat to human economic and social development. [1] More than 60 countries currently have carbon neutral emission reduction targets for 2050. As the world's major energy consumer and carbon emitter, General Secretary Xi Jinping, at the 75th UN General Assembly's general debate, also made clear China's vision of "carbon peaks" and "carbon neutrality." [2] Since the construction industry is a pillar industry of the current economic development and an important field of emission reduction, it is of great significance for China to explore the emission reduction path for the construction industry. [3] Therefore, this paper firstly analyzes the main factors affecting the carbon emissions in the construction industry with the method of grey correlation, and then studies the future trend of carbon emissions in the construction industry with the method of grey prediction, so as to provide a theoretical basis for the promotion of energy saving and emission reduction measures in the construction industry.

2. Research methodology

2.1 Grey correlation

Grey correlation is an analytical model that was put forward by Professor Deng Julong in 1982 to judge the degree of correlation between different factors based on a small amount of incomplete information. It mainly uses econometric modeling or statistical tools to do empirical research on the problem, and has the advantages of low demand for regularization of data and samples, convenient calculation and easy to grasp. [4] Firstly, this paper forms a reference series by non-dimensional treatment of carbon emissions, which is recorded as $X_0 = \{x_0(k),\ k = 1,2\cdots n\}$ and the energy consumption of electricity, coal and other sources is recorded as $X_i = \{x_i(k),\ k = 1,2\cdots n\}(i = 1,2\cdots m)$ after non-dimensional treatment. The grey relational grade formula is shown in Formula 1.

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$$R_i = \frac{1}{n}\sum_{k=1}^{n} \gamma[x_0(k),\ x_i(k)] \tag{1}$$

$$\Delta_{0i}(k) = |x_0 - x_i|,\ \ x(\min) = \min_i \min_k \Delta_{0i}(k),\ \ x(\max) = \max_i \max_k \Delta_{0i}(k) \tag{2}$$

Introducing the correlation coefficient between x0 and xi at k, then

$$\gamma[x_0(k),\ x_0(k)] = \frac{x(\min) + \rho x(\max)}{\Delta_{0i}(k) + \rho x(\max)} \tag{3}$$

Resolution coefficient, usually 0.5.

2.2 Grey prediction

Grey prediction is often used to deal with seemingly chaotic but intrinsic data and to make reasonable predictions of future trends. The grey prediction model has a single requirement for data and its principle is simple. The parameters and structure of the model can be changed with a little information. [5] The basic flow is shown in Figure 1.

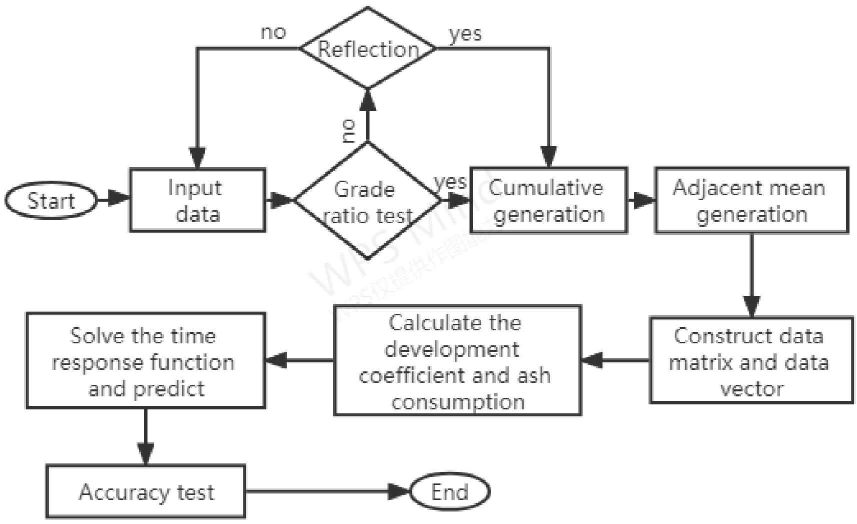

Figure 1: Grey prediction step

3. Empirical analysis

3.1 Data Source and Construction of Initial Indicator System

At the same time, according to the large amount of resources used in the construction industry, diesel, electricity, coke and other indicators as evaluation indicators.

3.2 Grey relational analysis

Table 1: Correlation between carbon emissions from the construction industry and related factors

Related factors	Practitioners	GDP	Rate of technical equipment	Population size	Gross output value of construction industry
Total carbon emissions from construction	0.641	0.584	0.974	0.583	0.582

Because the carbon emission of construction industry is affected by many factors, and the influence process of these factors is difficult to know, it can be regarded as a grey system. [6] Using the method of

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initial value,the two factors are treated with no dimension, and the correlation coefficient is calculated. The gray correlation result is shown in Table 1.

Overall, the five selected indicators are related to the construction industry carbon emissions, of which the highest correlation with the construction industry carbon emissions is the technical equipment rate, the lowest is the population. When the degree of association is more than 0.4, we think there is a correlation between them. When the degree of association is more than 0.6, we think there is a strong correlation between them. Therefore, energy saving and emission reduction of the construction industry can focus on the technical equipment rate and the number of employees to start.

3.3 Model Accuracy Test

The known actual and forecast values of China's carbon emissions for 2013-2020 are substituted into linear regression formulas to verify the reasonableness of the forecast values for China's carbon emissions for 2013-2022.

Table 2: Linear regression analysis results

	B	Standard error	Beta	t	p	VIF	R^2	F
Constant	-9.557	906.340	-	-0.011	0.992	-	0.904	F(1,6)=56.216, p=0.000
Actual value	1.001	0.134	0.951	7.498	0.000**	1.000		

From Table 2, we can see that the forecast is taken as independent variable and the actual is taken as dependent variable for linear regression analysis. The model formula is:

$$Y = aX + b \tag{4}$$

In the formula(4), Y represents the actual value, X represents the forecast value, a represents the value of regression coefficient and b represents the error term. So actual value=-9.557 + 1.001* forecast value, and the model R-square value is 0.904, which means that the forecast can explain 90.4% of the actual change reasons. When F-testing the model, we find that the model passes the F-test (F=56.216, p=0.000 <0.05), which means that there is a certain relationship between the predicted value and the actual value. The final analysis shows that the predicted regression coefficient value is 1.001 (t=7.498, p=0.000 <0.01), which means that there is a significant positive relationship between the predicted value and the actual value. This also shows that the forecasting model has certain accuracy and trend predictability for the development of China's carbon emissions and can be applied to the forecasting of its trend.

4. Trend analysis of carbon emissions in construction industry

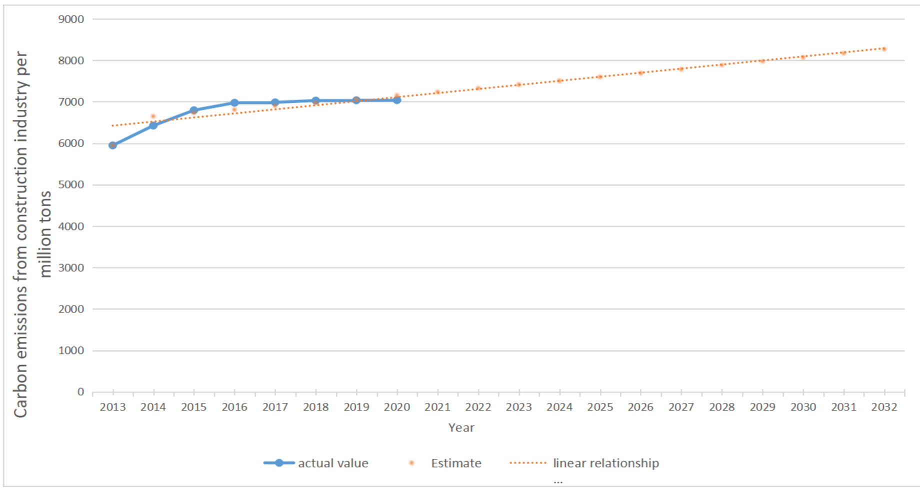

Figure 2: Predicted results

In order to better study the development trend of carbon emissions in construction industry, this

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paper takes China's carbon emissions from 2013 to 2020 as the original sequence and uses grey forecasting method to forecast China's construction carbon emissions. The results are shown in Figure 2.

Figure 2 shows that by 2030, China’s energy carbon emissions from the construction industry will exceed 80 million tons, and without intervention or energy transformation, China will be unable to achieve its carbon peak and carbon neutral targets.From Figure 2, we can see that China still has a high growth trend in carbon emissions, especially in 2030. Therefore, it is necessary to establish a low-carbon construction strategy and build a low-carbon technology system by strengthening the independent innovation capability of construction enterprises. Actively carry out energy-saving and emission reduction improvement on old buildings, accelerate the development and utilization of new energy, and vigorously supervise construction enterprises by establishing external supervision mechanism.

5. Conclusions and recommendations

In this paper, the GM (1, 1) grey prediction model is constructed by using the energy statistical yearbook of China, which is suitable for the prediction of carbon emissions in the future.

By predicting the carbon emission of construction industry, it can be found that China's goal of carbon peak and carbon neutral will be greatly disturbed if the traditional mode of production is not transformed. At present, China is in the transition period of energy transformation. This paper has a certain significance for the foundation of energy structure and targeted regulation. Reducing carbon emissions in the construction industry can be achieved by controlling the rate of technical equipment and the number of employees. As an important part of carbon neutralization in China, the decarbonization development of construction industry is very important. China's construction industry has great potential for low-carbon transformation, so we should give full play to the innovative potential of technology and industrial model, and actively transform to renewable energy, so as to become the pioneer in achieving China's carbon peak, carbon neutralization goals.

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